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**CORE**

DISCUSSION PAPER

Center for Operations Research  
and Econometrics

Voie du Roman Pays, 34  
B-1348 Louvain-la-Neuve  
Belgium

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**Tax treaties and the allocation  
of taxing rights with developing countries**

Dimitri PAOLINI<sup>1</sup>, Pasquale PISTONE<sup>2</sup>,  
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**Abstract**

Global income taxation in the country of residence is a legal dogma of international taxation. We question this dogma from the perspective of relations with developing countries from a legal and economic perspective, and make a modern and fair proposal for tax treaties. We will show under which conditions a developing and a developed country will voluntarily sign a tax treaty where information is exchanged truthfully and whether they should share revenues. Moreover, we will demonstrate how the conclusion of a tax treaty can assist in the implementation of a tax audit system.

**Keywords:** international corporate income taxation, tax treaties, revenue sharing, asymmetric information, uncertainty, locational decisions, principal-agent models.

**JEL Classification:** F53, H25, H87, D82

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<sup>1</sup> Università di Sassari, CRENoS and DEIR; Université catholique de Louvain, CORE, B-1348 Louvain-la-Neuve, Belgium; University of Luxembourg, CREA.

<sup>2</sup> University of Salerno and WU Vienna.

<sup>3</sup> Università di Cagliari and Sassari, CRENoS and DEIR.

<sup>4</sup> WU Vienna University of Economics and Business.

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# 1 Motivation

Global income taxation in the country of residence is a global legal dogma of international taxation (see Mc Daniel (2007); Fleming *et al.* (2009)). Conceived to fit relations between countries with symmetrical flows of capital, this dogma gradually spread throughout the world (see Christians (2010)). We question this result from the perspective of relations with developing countries for two reasons. From a legal perspective, expanding the taxing sovereignty beyond the national borders leads to overlaps with the sovereignty of the state of source and international double taxation may arise. From an accounting perspective, the deduction of the foreign tax by the country of residence<sup>1</sup>, reduces the possibilities of developing countries to attract foreign capital through tax policy. A reduction of such tax by the country of source turns into a lower deduction against taxes due in the country of residence. This achieves capital export tax neutrality, but prevents the reduction of taxes by countries that wish to attract foreign capital.

This paper regards this outcome in conflict with international tax justice and a fair allocation of taxing powers (see Pistone & Goodspeed (2010)). In particular, in the presence of unidirectional flows of income or capital, as for the relations with developing countries, worldwide income taxation by the country of residence allows in fact capital exporting countries to link up to their taxing jurisdiction income that has in fact been sourced or produced outside of it and thus interfere with the tax policy decisions of the country in connection with whose territory income was generated.

The features of this policy can be summarized as follows (see Brooks (2007); Pistone (2010)): When - as it is often the case - taxes levied in the developing

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<sup>1</sup>i.e. relief for juridical double taxation by the so-called foreign tax credit method.

country are lower than those applicable in the developed country, the latter will in fact levy its own taxes on income produced on the territory of the developing country under the noble justification that this will discourage developing countries from negotiating a race to the bottom with powerful multinational enterprises. Remarkably, however, developed countries often abstain themselves from compensating their more favorable domestic tax regimes, giving rise to some problems of compatibility with the non-discrimination principle under EU law. The even more remarkable effects of this international scenario is that multinational enterprises are stimulated to invest in complex (and expensive) international tax planning schemes in order to repatriate the investment of their capital through high tax jurisdictions that exempt foreign source income and an appropriate use of the diversity of tax treaties around the world (see Commission (2009) ).

The limited dialogue between legal and economic experts of taxation has so far lead to the conclusion that tax treaties have a limited impact on FDI. The first paper in the economic literature on the relationship between double tax agreements and foreign direct investment finds that there is a positive impact of US FDI towards other countries if a tax treaty has been signed (Barthel *et al.* (2010)). This result has been contested in the literature by an influential paper by Neumayer (2006), who concludes that treaties intend to reduce tax evasion rather than promote FDI. Based on a large international panel, Voget *et al.* (2011) have shown that double tax agreements exhibit a positive and significant impact on foreign direct investment. All of these results are based on the assumption, indeed very questionable from a legal perspective, that tax treaties present only marginal differences among them and can be streamlined along the patterns of model tax conventions (Lang *et al.* (2010)).

The evidence of in- and outbound investment concerning some tax havens and their relations with some developing countries can give an idea of how a modern view, that takes information sharing seriously, of the problem is needed, bringing together legal and economic experts of taxation to make use of tax treaties as an instrument for a fairer allocation of taxing powers and co-operation between developing and developed countries in order to allow both to preserve the integrity of their respective taxable base in the era of global fiscal transparency.

This paper aims at considering whether the shared allocation of taxing powers can be reshaped in a way that allows the developing country to have a fair share of the revenue originated from the exploitation of its territory (Benshalom (2010), Brauner (2010), Brooks (2009)). The goal of the joint legal and economic analysis is to secure for each developing country a sound and sustainable tax policy, based on the certainty of financial resources, sourced within the same country, consistently with the national policy objectives of such country and without external interferences (Brauner (2010), Christians (2010), Dagan (2010)).

From a legal perspective, states are free to decide whether or not to conclude a tax treaty. However, if a treaty exists, the contracting states are obliged to execute it in good faith, in compliance with the requirements of the Vienna Convention on the Law of Treaties. Therefore, insofar as a treaty exists and includes a clause on the exchange of information, the supply of information will be an ordinary consequence of the obligation to execute the treaty in good faith. Nevertheless, some years ago the OECD has clarified that requests for information not duly backed up by a precise documentation gathered in the framework of a preliminary auditing activity are to be regarded as fishing expedition and thus do not imply any obligation for the requested contracting state to supply the information.

From an economic perspective, information asymmetries as the one described above, where a developing country will have information on firms of developed countries can be solved by giving the developing country the right incentives to share this information. The key point of the analysis carried out here is to effectively implement these information sharing theories into tax treaties. In these theories information is considered a tradable good, and thus revenue sharing inevitably will come alongside the exchange of information. Until now such (economic) theories have found a limited attention among legal experts of taxation.

Within theoretical economics, some papers have analyzed the problem of information sharing and treaty in the issue of capital income taxation. Bacchetta & Espinosa (2000) have shown that information exchange can be supported only if governments interact repeatedly. Huizinga & Nielsen (2003) focus on the existence of bank profits to explain why countries might have an incentive to withhold information. Bank profits depend on the quantity of investments in a given country; hence, tax authorities have an incentive to withhold information. In a repeated version of the game, however, the authors show that information exchange can be sustained as an equilibrium if the discount factor is sufficiently small.

More particularly, Keen & Ligthart (2006) have identified the three main obstacles for information sharing. First, they mention that national tax authorities must have the legal right to share their information with other countries, which is, given the sensibility of the information, not straightforward. Second, similarly to Huizinga & Nielsen (2003), national authorities must be given the right to gain access to information residing with non-governmental institutions, such as banks. Here, too, bank secrecy laws may prevent the relevant disclosure of information.

Third, these institutions must possess the right information in an accessible form.

In a parallel paper, Keen & Ligthart (2007) apply the concept of information exchange to the EU savings directive. They compare a scenario without information exchange to a situation with the exchange of information, where a country can unilaterally set a withholding tax to retain part of the tax revenues. Whilst they do not explicitly state it in their paper, the model could be used to analyze the benefits of signing a tax treaty with revenue sharing and information exchange, and can thus be considered a special case of the analysis carried out here.

The first empirical application that investigates the motives for countries to sign a tax treaty has been carried out by Voget *et al.* (2011). They find that apart from reducing or eliminating crossborder double taxation, tax treaties are also signed to obtain a legal instrument for the exchange of tax information. In this respect, this last paper provide evidence for the theory presented in this paper.

The current concern to move toward global fiscal transparency has increased the general awareness of the importance to secure an effective exchange of information through tax treaties. Therefore, regardless of whether tax treaties in fact affect FDI, this study aims at establishing a fair and effective exercise of the taxing sovereignty on the basis of tax treaties in relations with developing countries through a mechanism that pursues an effective exchange of information.

The authors regard tax treaties as the only instrument through which developed countries can obtain the sufficient and objectively reliable information for exercising their sovereignty on revenue from developing countries (see Christians (2005)). However, developing countries not necessarily dispose of the relevant infrastruc-

ture and auditing system for supplying that information, which also entails relevant costs for them. Furthermore, insofar as the tax treaty flow of information does not work properly, developed countries find themselves in a similar situation to that arising in the absence of a tax treaty. Accordingly, for instance, they would be unable to check whether transfer pricing within multinational groups effectively corresponds to the function performed by companies in developing countries in respect of income sourced in those countries. In such cases, firms may more easily hide all or a part of their revenues.

This paper elaborates a model for achieving a system that allows for an effective and sustainable exchange of information in situations with unidirectional flows of income and capital, assuming this as the situation most frequently occurring in relations with developing countries. The analysis also takes into account the possible impact of an effective exchange of information on the mobility of investment by multinational enterprises at the international level, assuming two scenarios in which firms respectively (i) can and (ii) cannot move to other developing countries.

The mechanism contemplated in this study allocates taxing powers in a way that makes it affordable for developing countries to sustain the costs of an effective auditing carried out at the standards required by global fiscal transparency (and in certain cases even to introduce such a system of auditing) and exercise their tax sovereignty in compliance with their own policy. The allocation of taxing powers allows one contracting state (normally the developed country) to tax the income up to arm's length value and the other contracting state (normally the developing country) to tax the remaining part of the income<sup>2</sup>.

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<sup>2</sup>A good example of this is the predetermined mechanism currently applicable on a unilateral basis for determining transfer pricing in the Brazilian tax system.



In the following, we will present the design for a modern and fair tax treaty. The treaty is modern in the sense that it takes information sharing between contracting states seriously. It is fair in the sense that it will comprise revenue sharing of tax revenues collected by the developed country. We will assume that both contracting states are small, so that strategic considerations to change tax rates are absent, and we can therefore treat tax rates as given. For the sake of simplicity we also assume that governments are Leviathan, and maximize government revenues.

The paper proceeds as follows. In the next section, we will discuss the situation if firms are immobile. Though this scenario may not be realistic, it is simple and yet permits us to show all the main results. We will relax this assumption in section 3. Within each section, we will need to solve four distinguished cases, depending on whether a treaty exists or not, and whether the developing country audits firms and gathers the necessary information for information sharing or not. We will describe the benchmark case without a treaty in the first subsection. Here we will assume that the developing country adopts the tax credit method, and unilaterally allows full deduction of all tax payments to the developing state. In the second subsection, we will discuss the alternative case of a treaty, where we assume that countries split the tax base according to the arm's length transfer pricing principle. In order to obtain information about its taxpayers from the developing country, the developed country may be willing to share part of its tax revenues, and we will indicate the range of revenue sharing where a tax treaty is feasible.

## 2 No firm relocation

We consider  $n \in \mathfrak{R}^+$  identical multinational firms that produce a fixed quantity,  $q$ , of a homogeneous good in a developing country  $U$ . We assume, for the ease of exposition, that firms sell the  $q$  goods in a developed country  $D$  at a price  $p_d \in \mathfrak{R}^+$ .<sup>3</sup> The sales price  $p_d$  is constant and known to both countries. We will normalize  $p_d = 1$ .

Firms produce with constant marginal costs  $\tilde{c}_i$ . These costs, by hypothesis, are stochastic and unknown to both countries. For the sake of simplicity we assume that each  $\tilde{c}_i$  is a random variable which can assume two values: *high* (with probability  $\rho \in [0, 1]$ ) or *low* (with probability  $(1 - \rho)$ ), i.e.  $\tilde{c}_i \in \{c_l, c_h\}$ <sup>4</sup>. Note that the developed country cannot observe the true realization of individual production cost  $\tilde{c}_i$ , but knows the probability  $\rho$ , so that it can foresee both the amount of firms producing with a low and high marginal costs.

As quantity neither influences marginal costs nor the sales price, we will assume that each firm produces exactly one unit of the good,  $q = 1$  without loss of generality. Expected gross operating profits of firms are therefore given by  $\bar{\pi}_i = 1 - \bar{c}$ , where  $\bar{c} = E(\tilde{c}_i) = \rho c_h + (1 - \rho)c_l$ . In the absence of a tax audit system, firms can claim any reasonable cost to either country<sup>5</sup>.

Both countries can and - in the absence of a tax treaty - will tax each firm  $i$ 's global income  $\tilde{\pi}_i$ . In particular,  $D$  can levy a corporate income tax on revenues in  $D$  even in absence of a subsidiary. We thus exclude headquarter shopping. Finally,

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<sup>3</sup>We assume that consumers in  $D$  are immobile.

<sup>4</sup>with  $0 < c_l < c_h < p_d = 1$ .

<sup>5</sup>In our case, firms can claim at most costs of  $c_h$ .

we assume that there are no firms that produce in  $D$  and sell in  $U$ .

The developing country  $U$  can learn the actual realization of each firm's  $\tilde{c}_i$  bearing a (sunk) cost  $M(n)$ , with  $\partial M(\cdot)/\partial n > 0$ . We assume that there are fixed costs of implanting a tax audit system,  $M(0) > 0$ . The developed country  $D$  cannot observe or learn the true realization of  $\tilde{c}_i$  and must therefore trust either the firm or the developing country  $U$ 's claim.

## 2.1 No Treaty

In the absence of a tax treaty and firm relocation, the developing country must still decide whether to implement a tax audit system and thereby reveal information about its resident firms, in particular about their true costs of production. The developing country  $U$  will decide to audit if and only if tax revenues with implementation of an audit system, that we denote with  $T_u^{na}$ , are (weakly) greater than tax revenues without audit,  $T_u^{nn}$ ,

$$T_u^{na} = nt_u(1 - \bar{c}) - M(n) \geq nt_u(1 - c_h) = T_u^{nn} \quad (1)$$

where  $t_u \in [0, 1]$  is the tax rate in country  $U$ . This condition is satisfied if and only if audit costs are (weakly) inferior to the tax revenue gain. Formally,

$$M(n) \leq nt_u(c_h - \bar{c}) \quad (2)$$

If no treaty is signed and therefore no information is exchanged, country  $D$  has to rely on each firm  $i$ 's declaration about costs, irrespective of the implementation of an audit system in the developing country  $U$ . Since the developed country  $D$  does not have the necessary information and no way to procure it, all firms will declare **high** costs i.e.  $c_i = c_h \forall i \in n$  and will deduct taxes paid in country  $U$  that depends on the implementation decision of country  $U$ .

In the absence of a tax audit system in the developing country, both countries will tax the same tax base, and tax revenues in country  $D$  will equal,

$$T_d^{nn} = n(t_d - t_u)(1 - c_h) \quad (3)$$

where  $t_d \in [0, 1]$  is the tax rate in country  $D$ . By contrast, if  $U$  has implemented a tax audit system, firms will declare true costs to country  $U$  and therefore deduct higher taxes in country  $D$ . In this case tax revenues will equal,

$$T_d^{na} = n(t_d - t_u)(1 - c_h) - nt_u(c_h - \bar{c}) \quad (4)$$

In the absence of audit, firms hide part of their revenues and therefore evade an amount of taxes equal to  $nt_d(c_h - \bar{c})$ .

Without an audit system we define the global tax revenues as:

$$T^{nn} = T_u^{nn} + T_d^{nn} = nt_d(1 - c_h) \quad (5)$$

In the presence of audit, the global tax revenues is:

$$T^{na} = T_u^{na} + T_d^{na} = nt_d(1 - c_h) - M(n) \quad (6)$$

It is important to understand that without a treaty the global taxation is a decreasing function of the audit sunk cost  $M(n)$ .

## 2.2 A Treaty

Tax treaties with developing countries typically follow the UN model tax treaty, where countries agree to exchange information and eliminate double taxation by splitting firm revenues according to arm's length transfer pricing rules. The arms length principle defines the just transfer price as average production costs plus a

mark-up. We will assume that this transfer price equals  $\alpha \tilde{c}_i$ , where  $\alpha > 1$ .

Both countries will lose part of the tax base when signing a treaty. The developed country  $D$  could gain from a double tax treaty if this reveals true production costs of firms. However, the developing country  $U$  would unconditionally lose from a tax treaty, as it could observe true production costs even in the absence of a treaty through auditing. Developing countries will therefore only voluntarily sign tax treaties if an element of revenue sharing is included in the treaty. In order to obtain a voluntary agreement, the developed economy,  $D$ , will propose a compensation fee  $f$  for the revelation of information about every firm. We assume that the developed country will offer  $f_l$  if revealed costs of the firm are *low* and  $f_h$  if revealed costs were *high*.

The timing is as follows: first the developed country  $D$  chooses and announces  $f_h$  and  $f_l$  <sup>6</sup>. Then the developing country  $U$  decides whether to sign the treaty or not. Finally, after realization of  $\tilde{c}_i$  (which is not observable by the developed country), if  $U$  signed the contract, it audits the firms, collects taxes if any and pays  $\eta \cdot f_h + (n - \eta)f_l$  (where  $\eta \in [0, n]$  is the number of firms whose actual  $c_i = c_l$ ) to  $D$ .

In order to induce  $U$  to sign the treaty and to give a true declaration about the actual realization of each  $c_i$ , the developed country  $D$  needs to choose the lump sum fee vector  $f$  according to the following condition:

1. *Incentive compatibility (IC)* When a state  $\pi_\eta$  <sup>7</sup> actually happened, the tax revenues of the developing country when it declares  $\pi_\eta$  must be (weakly)

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<sup>6</sup>So  $f_h \leq f_l$

<sup>7</sup>In this state of the world just  $\eta$  firms make a low revenue while the others  $(n - \eta)$  make the high one.

greater than its tax revenues when it declares  $\pi_j$  for all  $j \in [0, n]$  different from  $\eta$ ;

2. *Participation constraint (PC)* the expected tax revenues of the developing country when it accepts the treaty must be (weakly) greater than what it gets when it refuses.

Suppose that  $D$  sets  $f_h \neq f_l$ , then  $U$  has an incentive to misreport the correct transfer price in order to make an unfair profit. So, in order to satisfy the incentive compatibility constraint (IC) and then give the incentive to share the correct information to  $U$ , the developed country  $D$  has to set a unique fee  $f = f_l = f_h$ .

In order to satisfy the participation constraint (PC) the choice of  $f$  depends on whether in the absence of a treaty the developing country audits or not, equation (2). We analyze in the following before if condition (2) is satisfied and in the following if it is not.

### 2.2.1 A treaty with audit already in place

If the **tax revenue gain** is (weakly) greater than **audit costs**, condition (2), then implementing a monitoring system does not depend on the treaty since it will be implemented anyway. If this is the case then the developing country  $U$  will sign the treaty if tax revenues plus revenue sharing  $nf^{ta}$  exceeds tax revenues in the absence of a treaty,

$$T_u^{ta} = nt_u(\alpha - 1)\bar{c} - M(n) + nf^{ta} \geq T_u^{na} \quad (7)$$

The previous equation is satisfied if and only if the tax revenue loss of the reduced tax base audit costs are (weakly) inferior to the tax revenue gain. Formally, the PC condition is satisfied iff,

$$\underline{f}_u^{ta} = t_u(1 - \alpha\bar{c}) \leq f^{ta} \quad (8)$$

where  $\underline{f}_u^{ta}$  is the minimum level of revenue sharing for which country  $U$  with an audit system will be willing to sign the treaty.

The developed country  $D$  will sign the treaty when audit was already in place if and only if tax revenues it receives with the treaty,  $T_d^{ta}$ , are greater than tax revenues if it does not sign,

$$T_d^{ta} = nt_d(1 - \alpha\bar{c}) - nf_u^{ta} \leq n(t_d - t_u)(1 - c_h) - nt_u(c_h - \bar{c}) = T_d^{na} \quad (9)$$

This gives the maximum fee the developed country is willing to pay,

$$\bar{f}_d^{ta} = t_d(c_h - \alpha\bar{c}) + t_u(1 - \bar{c}) \geq f_u^{ta} \quad (10)$$

where  $\bar{f}_d^{ta}$  is the maximum level of revenue sharing for which country  $D$  will be willing to sign the treaty with a developing country with an audit system.

A treaty is feasible if and only if condition 8 and 10 are both satisfied, i.e.  $\underline{f}_u^{ta} \leq f_u^{ta} \leq \bar{f}_d^{ta}$ .

Given equation 6 and the global taxation with the treaty:

$$T^{ta} = nt_d(1 - \alpha\bar{c}) + nt_u(\alpha - 1)\bar{c} - M(n) \quad (11)$$

we find that  $T^{ta} = T^{na} + n\bar{f}_d^{ta} - n\underline{f}_u^{ta}$  which shows that a treaty is feasible iff the total tax revenues is increasing with the treaty.<sup>8</sup>

### 2.2.2 A treaty initially without audit

If **audit costs** are greater than the **tax revenue gain**,  $U$  will not implement the audit system in the absence of the treaty. This means that in the absence of a

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<sup>8</sup>We discuss under which conditions a treaty increase the tax revenue in the paragraph 2.2.3.

treaty it will get a payoff of  $T_u^{nn}$ , defined in equation (1) above, since each firm  $i$  will declare high costs  $c_h$ , and it will get  $T_u^{tn}$  if it signs the treaty. The problem of the developing country  $U$  consists of choosing whether to sign the treaty or not in order to maximize its tax revenues. It will accept the treaty iff:

$$T_u^{tn} = nt_u(\alpha - 1)\bar{c} - M(n) + nf^{tn} \geq nt_u(1 - c_h) = T_u^{nn} \quad (12)$$

The previous condition is satisfied if and only if the fee plus the net tax revenues gain are (weakly) greater than the cost of the audit system, or

$$\underline{f}_u^{tn} = t_u(1 - \alpha\bar{c}) + \frac{M(n)}{n} - t_u(c_h - \bar{c}) \leq f^{tn} \quad (13)$$

where  $\underline{f}_u^{tn}$  is the minimum level of revenue sharing for which country  $U$  without an audit system will be willing to sign the treaty.

In addition to the compensation of the loss of tax base as in condition (8) above, the developed economy must now also compensate the developing economy for the implementation of a tax audit system, which is the last part of the above condition (13) and replicates condition (2).

Similarly as above, the developed country  $D$  will sign the treaty when audit was not already in place if and only if the tax revenues it receives with the treaty exceed tax revenues without the treaty,

$$T_d^{nn} = n(t_d - t_u)(1 - c_h) \leq nt_d(1 - \alpha\bar{c}) - nf^{tn} = T_d^{tn} \quad (14)$$

which leads to,

$$\bar{f}_d^{tn} = t_d(c_h - \alpha\bar{c}) + t_u(1 - c_h) \geq f^{tn} \quad (15)$$

where  $\bar{f}_d^{tn}$  is the maximum level of revenue sharing for which country  $D$  will be willing to sign the treaty with a developing country without an audit system.



The first term is the tax gain when a treaty is signed. The second by contrast is the tax revenue loss due to the ceasure of taxing rights to the developing country  $U$ . The two conditions for the developed economy, equations (10) and (15), differ only by the amount  $t_u(c_h - \bar{c})$ . If no audit system was in place before the treaty, the developed country can offer a lower compensation for the developing country  $U$ , as it can fully appropriate the higher tax revenues of the developing country  $U$  resulting from auditing.

A treaty is feasible if and only if conditions 13 and 15 are both satisfied, i.e.  $\underline{f}_u^{tn} \leq f^{tn} \leq \bar{f}_d^{tn}$ .

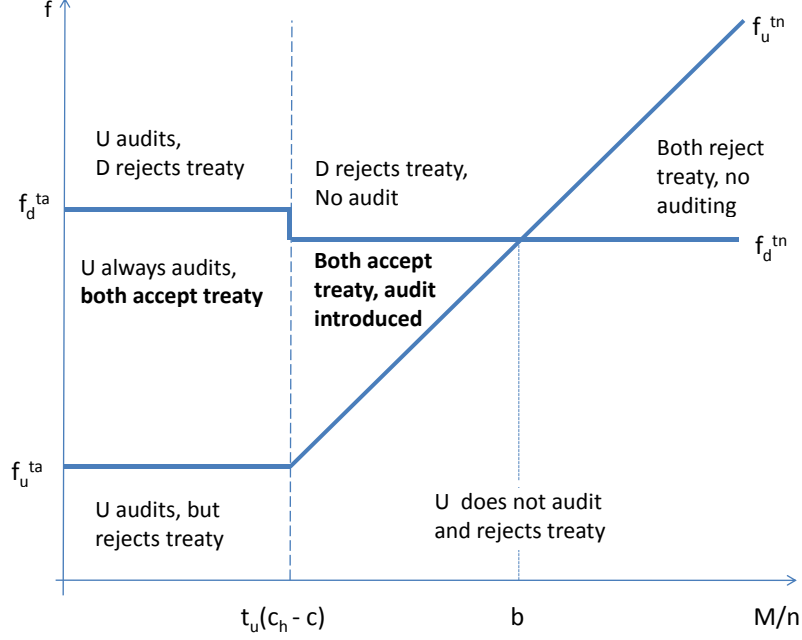
As before if the above condition is met then the total tax revenues is increasing with the treaty. Let us define the global taxation with the treaty as:

$$T^{tn} = nt_d(1 - \alpha\bar{c}) + nt_u(\alpha - 1)\bar{c} - M(n) \quad (16)$$

and recalling equation 5 we get  $T^{tn} = T^{nn} + n\bar{f}_d^{tn} - n\underline{f}_u^{tn}$ .

### 2.2.3 Discussion

Jointly equations (10) and (15) give the maximum level of revenue sharing still acceptable for the developed economy  $D$ . Equations (8) and (13) define the minimum level of revenue sharing that the developing country  $U$  is willing to accept. Equations (10) and (8) hold for cases where an audit system is already in place,  $M(n) \leq nt_u(c_h - \bar{c})$ , whereas equations (15) and (13) hold otherwise. We can plot these conditions in a graph in the  $f$  to  $\frac{M(n)}{n}$  space.



We can define the difference  $b$  between the revenue sharing fee offered by the developed country and the revenue sharing fee requested by the developing country as

$$b = \bar{f}_d^{ta} - \underline{f}_u^{ta} = t_d(c_h - \alpha \bar{c}) + t_u(\alpha - 1)\bar{c} \quad (17)$$

This indicates the bargaining space that the two countries have in case an audit system is already in place. We find that a tax treaty can be welfare improving for both countries if  $b \geq 0$ . Except for the unlikely case that the average arm's length price exceeds the maximum cost by a very large amount, we can ensure that a tax treaty is possible. Moreover, we can show that in this case, a tax treaty can also assist in the implementation of a tax audit system if  $\bar{f}_d^{tn} - \underline{f}_u^{ta} \Leftrightarrow t_d \geq t_u$ . Finally, note that if unit auditing costs exceed the bargaining space  $M(n)/n \geq b \Leftrightarrow \underline{f}_u^{tn} - \bar{f}_d^{tn}$ , and no voluntary treaty is feasible.

The transfer price  $\alpha$  is decided by international law and therefore given. If  $\alpha$  were freely choosable by both contracting parties, we could identify the lowest transfer price for which the developing country is indifferent between signing the treaty or not:

$$\alpha = \begin{cases} \frac{1}{\bar{c}} & \text{if } M(n) \leq nt_u(c_h - \bar{c}) \text{ with audit system} \\ \frac{1}{\bar{c}} \left(1 + \frac{M(n)}{nt_u} + \bar{c} - c_h\right) & \text{if } M(n) \geq nt_u(c_h - \bar{c}) \text{ without audit system} \end{cases} \quad (18)$$

As can be noticed above if the developing country has already an audit system this optimal choice depends on the developing country tax base  $t_u$ . This feature hampers the possibility to set a unique international standard transfer price.

The model implies an unambiguously positive level of revenue sharing. The compensation will therefore be the result of a bargaining process and - depending on the bargaining power of the two parties - fall in between the minimum level of revenue sharing required by the developing economy  $U$  and the maximum level of revenue sharing offered by the developed country  $D$ .

Interestingly, a treaty can stimulate a developing country to introduce a tax audit system together with a tax treaty, even if initially an audit system is too expensive to be implemented. As long as the tax level is given the treaty acts as it increases the tax rate in  $U$  and the tax base in  $D$ . Moreover a treaty can end the evasion phenomenon since firms will declare truthfully. Obviously, there will be no treaty with developing countries that exhibit excessive audit costs.

We were able to show under which conditions countries are willing to sign a tax treaty voluntarily where they truthfully exchange information. We have been able to prove that such treaties will only come to place if the country in need of in-

formation is willing to share a nonzero part of these additional revenues with the other country. We were also able to show that the conclusion of a treaty can induce the developing country to implement a tax audit system. In the next section, we will analyze whether these conclusions hold under the obvious possibility that firms may leave (or enter) a country that has just signed a treaty.

### 3 Relocation decision

Capital is mobile internationally, and firms can relocate their production at will to any third country upon bearing a relocation cost  $k$ . For simplicity, we assume that third countries levy the same tax rate  $t_u$  as the developing country  $U$  under consideration. Such a common tax rate can be the outcome of tax competition.

#### 3.1 No treaty

First, suppose that the developing country has neither a tax treaty nor a tax audit system. Then the firm will claim as before high costs in both countries and be taxed according to the global income principle, yielding expected profits of

$$\pi^{ns} = (1 - \bar{c}) - t_d(1 - c_h) \quad (19)$$

in case it decides to stay. Profits are given by revenues (normalized to unity) minus expected production costs  $\bar{c}$ , and minus tax payments on declared profits to the developed country  $D$ , since taxes paid in  $U$  can be deducted. Suppose, now, that firms can move paying a reallocation cost  $k$ . The profit of a single firm in case it decides to move to another country without audit and treaty will be

$$\pi^{nn} = \pi^{ns} - k \quad (20)$$

In the absence of neither a proper tax audit nor a tax treaty, the foreign tax credit method impedes firms to relocate as profits of relocating firms (20) are strictly

lower than profits of remaining firms (19),  $\pi^{nnn} \leq \pi^{nns}$ . By the same token, the foreign tax credit method also impedes tax competition between developing countries, as their respective tax rates are irrelevant for the locational decision of foreign firms. Tax revenues in the developed and the developing country respectively are  $T_u^{nns} = nt_u(1 - c_h)$  and  $T_d^{nns} = n(t_d - t_u)(1 - c_h)$ .

Second, suppose now that the developing economy implements a tax audit system, but does not communicate the findings to the developed economy due to the lack of a treaty. If the developed country  $D$  offers tax deductions following the foreign tax credit method, firms can deduct all the taxes paid in  $U$ . Profits in the case firms do not relocate are identical to the case in the absence of auditing (19),  $\pi^{nas} = \pi^{nns}$ . Profits in the case firms relocate are also identical to the case in the absence of auditing (20),  $\pi^{nan} = \pi^{nnn}$ . Firms will again decide to remain in the developing country  $U$  given (weakly) positive moving costs,  $k \geq 0$ .

Tax revenues in the developed country now differ since firms deduct a higher amount of taxes. Hence  $T_d^{nas} = nt_d(1 - c_h) - nt_u(1 - \bar{c})$ , whereas for the developing country they change to  $T_u^{nas} = nt_u(1 - \bar{c}) - M(n)$ . As opposed to the case without auditing, the developed country  $D$  will now receive lower tax revenues as firms will now deduct higher tax payments to the developing country  $U$  of the amount  $t_u(c_h - \bar{c})$ . The developing country by contrast gains these tax revenues, but has to pay auditing costs of  $M(n)$ . The developing country  $U$  prefers to implement a tax audit system if  $T_u^{nas} \geq T_u^{nns}$ , or

$$M(n) \leq nt_u(c_h - \bar{c}). \quad (21)$$

This means that an audit system will be implemented if the tax gain is greater than auditing costs.

### 3.2 A Treaty

As in the absence of a relocation decision, we will consider a treaty with information exchange and revenue sharing. Note that in the absence of auditing, the developed economy will not benefit from a treaty, and will therefore not be willing to share tax revenues. This case is therefore identical to the no treaty/no audit case above.

With the conclusion of a tax treaty, firms are now aware that information about their true cost structure will be shared with the developed economy. By contrast, a treaty eliminates double taxation according to the global income principle with full foreign tax credit, and firms will now declare part of their profits in the developing country  $U$ , which might offer lower tax rates. If the prior effect dominates, firms can expect to pay higher taxes and may consider relocation.

In order to prevent capital flight, the developing country  $U$  may consider the possibility to pay a subsidy,  $s$ , in order to induce firms to stay. We can think of these subsidies either as a reduction in the tax rate offered to firms considering relocation, where the effective tax rate will be  $\tau_u = t_u - s/(\alpha\bar{c} - \bar{c})$ , or a transfer in kind (e.g. infrastructure), which would reduce production costs. In either case, the subsidy given is a form of tax competition. Profits in case the firm leaves are given by equation (20) above, whereas if the firm remains they are given by

$$\pi^{tas} = (1 - \bar{c}) - t_u(\alpha - 1)\bar{c} - t_d(1 - \alpha\bar{c}) + s \quad (22)$$

The optimal subsidy to firms now equals

$$s \geq t_u(\alpha - 1)\bar{c} + t_d(c_h - \alpha\bar{c}) - k \quad (23)$$

The first part represents taxes paid in  $U$ , whereas the second term controls for the once evaded taxes in  $D$ , and the last part is the moving cost. Firms can

therefore claim all taxes paid to the developing country  $U$  short of relocation costs  $k$ , and will receive the additional taxes paid to the developed country  $D$  back from the developing country. With very high relocation costs, this subsidy could in theory be negative, and developing countries could in principle appropriate these locational rents. Substituting subsidies from above, we find that tax revenues will equal

$$T_u^{tas} = n\underline{f}_u^{tas} + nk - nt_d(c_h - \alpha\bar{c}) - M(n) \quad (24)$$

Note that tax revenue depends on tax rates in the developed economy due to the subsidy. The developed economy will receive revenues equal to

$$T_d^{tas} = nt_d(1 - \alpha\bar{c}) - n\bar{f}_d^{tas} \quad (25)$$

### 3.3 Discussion

Once again, we have to distinguish two cases indicated by condition (21), whether audit is already in place before signing the treaty,  $M(n) \leq nt_u(c_h - \bar{c})$ , or not. On the one hand, if audit was already in place before signing the treaty, the developing country will accept the treaty iff tax revenues under a treaty exceed tax revenues without a treaty,  $T_u^{tas} \geq T_u^{nas}$  or

$$\underline{f}_u^{tas} \geq t_d(c_h - \alpha\bar{c}) + t_u(1 - \bar{c}) - k$$

The developed country by contrast will accept the treaty iff tax revenues under a treaty exceed tax revenues without a treaty,  $T_d^{tas} \geq T_d^{nas}$  or

$$\bar{f}_d^{tas} \leq t_d(c_h - \alpha\bar{c}) + t_u(1 - \bar{c})$$

Note that  $\underline{f}_u^{tas} = \bar{f}_d^{tas} - k$ . Hence the developed country  $D$  will be willing to offer a revenue sharing fee that will exceed the revenue sharing fee requested by the developing country  $U$  for any nonnegative relocation costs  $k \geq 0$ . The treaty

surplus  $b$  that was generated in the absence of firm relocation is now entirely absorbed by firms through subsidies. By contrast, the relocation costs  $k$  generates a different rent that opens a new bargaining space  $k$ . Let us define global taxation as the sum of both countries' tax revenues:  $T^{nas} = T_d^{nas} + T_u^{nas} = nt_d(1 - c_h) - M(n)$  is the global taxation if any treaty is not signed and  $T^{tas} = T_d^{tas} + T_u^{tas} = nt_d(1 - c_h) + nk - M(n)$ . So:

$$T^{tas} \geq T^{nas} \rightarrow k > 0$$

This means that the global taxation is increasing in the treaty if and only if there exists a positive cost for each firm to move.

On the other hand, if auditing was initially not in place and condition (21) was not satisfied,  $M(n) > nt_u(c_h - \bar{c})$ , the developing country will accept the treaty if and only if tax revenues under a treaty exceed tax revenues without a treaty,  $T_u^{tns} = T_u^{tas} \geq T_u^{nns}$  or

$$\underline{f}_u^{tns} \geq t_d(c_h - \alpha\bar{c}) + t_u(1 - c_h) + \frac{M(n)}{n} - k$$

The developed country by contrast will accept the treaty iff tax revenues under a treaty exceed tax revenues without a treaty,  $T_d^{tns} = T_d^{tas} \geq T_d^{nas}$  or

$$\bar{f}_d^{tns} \leq t_d(c_h - \alpha\bar{c}) + t_u(1 - c_h)$$

The minimum revenue sharing fee acceptable for the developing country will be lower than the maximum revenue sharing fee offered by the developed country if

$$M(n) \leq nk - nt_d(1 - c_h)$$

Together with condition (21), This identifies the space were a treaty is feasible even if there was no auditing initially, namely when relocation costs are high, or

$$k \geq t_d(1 - c_h) + t_u(c_h - \bar{c})$$



As before the global taxation is  $T^{nns} = T_d^{nns} + T_u^{nns} = nt_d(1 - c_h)$  if any treaty is not signed and if not is  $T^{tns} = T_d^{tns} + T_u^{tns} = nt_d(1 - c_h) + nk - M(n)$ . So:

$$T^{tas} \geq T^{nas} \rightarrow k > \frac{M(n)}{n}$$

This means that the global taxation is increasing with the treaty if and only if the cost for each firm to move is greater than the cost for the developing country to audit it.

Notice that for tax rates in the developed economy exceeding tax rates in the developing economy,  $t_d > t_u$ , the subsidy is increasing in the arm's length pricing mark-up  $\alpha$ . Developing countries need not pay a subsidy if the mark-up is defined according to

$$\alpha - 1 = \frac{t_d(c_h - \bar{c}) - k}{(t_d - t_u)\bar{c}}$$

Substituting the minimum subsidy feasible from equation (23) into the profit function (22), we find that net profits will equal  $\pi^{tas} = (1 - \bar{c}) - t_d(1 - c_h) - k$ . Together, the developed and the developing country can levy at most the developed countries tax rate on the minimum declarable taxbase  $1 - c_h$  and skim off relocation costs. (Tax) revenues in the developing economy will consist of profit taxation of firms, subsidies to firms, revenue sharing from the developed country, and audit costs.

## 4 Conclusions

This paper has departed from the observation that global income taxation in the country of residence is a global legal dogma of international taxation. We have questioned this dogma from the perspective of relations with developing countries from a legal and economic perspective, and made a modern and fair proposal for tax treaties. We have shown under which conditions a developing and a developed

country will voluntarily sign a tax treaty where information is exchanged truthfully and when they should share revenues. Moreover, we have demonstrated how the conclusion of a tax treaty can assist in the implementation of a tax audit system.

## References

- BACCHETTA, P., & ESPINOSA, M.P. 2000. Exchange of information Clauses in International Tax Treaties. *International Tax and Public Finance*, **7**, pp. 275–293.
- BARTHEL, F., BUSSE, M., KREVER, R., & NEUMAYER, E. 2010. The Relationship between Double Taxation Treaties and Foreign Direct Investment. *M. Lang, P. Pistone, J. Schuch, C. Staringer, A. Stock and M. Zagler (eds.): Tax Treaties: Building Bridges between Law and Economics, Amsterdam: IBFD*, pp. 3–18.
- BENSHALOM, I. 2010. The New Poor at Our Gates: Global Justice Implications for International Trade and Tax Law. *New York University Law Review*, **89(1)**, pp. 101–177.
- BRAUNER, Y. 2010. A Framework for an Informed Study of the Realistic Role of Tax in a Development Agenda. *University of British Columbia Law Review*, **42(2)**, pp. 275–330.
- BROOKS, K. 2007. Tax Treaty Treatment of Royalty Payments from Low-Income Countries: A Comparison of Canada and Australia’s Policies. *eJournal of Tax Research*, **5(2)**, pp. 168–197.

- BROOKS, K. 2009. Inter-Nation Equity: The Development of an Important but Underappreciated International Tax Value. *Krever, R., Head, J.G. (eds.), Tax Reform in the 21st Century, Kluwer Law International*, pp. 471–497.
- CHRISTIANS, A. 2005. Tax Treaties for Investment and Aid to Sub-Saharan Africa: A Case Study. *Brooklyn Law Review*, **71**, pp. 639–700.
- CHRISTIANS, A. 2010. Global Trends and Constraints on Tax Policy in the Least Developed Countries. *University of British Columbia Law Review*, **42(2)**, pp. 239–274.
- COMMISSION, NORWEGIAN GOVERNMENT. 2009. *Report by Norwegian Government Commission on Capital Flight from Poor Countries, submitted to the Ministry of Foreign Affairs on 18 June 2009, NOU - Official Norwegian Reports 2009:19. The English translation of the report is currently available at <http://www.regjeringen.no/nb/dep/ud/dok/nou-er/2009/nou-2009-19-2.html?id=572129>.*
- DAGAN, T. 2010. Just Harmonization. *University of British Columbia Law Review*, **42(2)**, pp. 331–362.
- FLEMING, J.C., PERONI, R., & SHAY, S. 2009. Worse than Exemption. *Emory Law Journal*, **59(1)**, pp. 79–149.
- HUIZINGA, H., & NIELSEN, S. B. 2003. Withholding Taxes or Information Exchange: How to Tax International Interest Flows. *Journal of Public Economics*, **87**, pp. 39–72.
- KEEN, M., & LIGTHART, J. E. 2006. Information Sharing and International Taxation. A Primer. *International Tax and Public Finance*, **13(1)**, 81–110.

- KEEN, M., & LIGTHART, J. E. 2007. Revenue Sharing and Information Exchange under Non-discriminatory Taxation. *Scandinavian Journal of Economics*, **109(3)**, pp. 487–504.
- LANG, M., PISTONE, P., SCHUCH, J., STARINGER, C., & ZAGLER, M. (eds). 2010. *Tax Treaties from a Legal and Economic Perspective*. IBFD Publications, Amsterdam.
- MC DANIEL, P. 2007. Territorial vs Worldwide International Tax Systems: Which is Better for the U.S. *Florida Tax Review*, **8**, pp. 263–291.
- NEUMAYER, E. 2006. Do double taxation treaties increase foreign direct investment to developing countries? *Journal of Development Studies*, **43(8)**, pp. 1495–1513.
- PISTONE, P. 2010. Tax Treaties with Developing Countries: a Plea for New Allocation Rules and a Combined Legal and Economic Approach. IBFD Publications, Amsterdam.
- PISTONE, P., & GOODSPEED, T.J. 2010. Rethinking tax jurisdictions and relief from international double taxation with regard to developing countries: Legal and economic perspectives from Europe and North America. *Pages 13–36 of: ZAGLER, M. (ed), International Tax Coordination*. Routledge, Abingdon.
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